International Space Station (ISS)
Reference Document

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1.0 Acronyms

APM	Attached Pressurized Module
ASCB	Avionics Control Board
C&T	Command and Tracking
CBM	Common Berthing Mechanism
CCS	Command and Control Software
CMG	Control Moment Gyro
CSP	Computer Safety Panel
DDCU	Direct Current-to-Direct Current Converter Unit
DMS	Data Management System
EATCS	External Active Thermal Control System
ECLSS	Environmental Control and Life Support System
ECZ	External Control Zone
EPS	Electrical Power System
EXT	External
FDIR	Failure Detection, Isolation and Recovery
FQT	Formal Qualification Tes
GNC	Guidance, Navigation and Control
HCS	Hub Control Software
IAL	IV&V Analysis Level
IDD	Interface Definition Document
INTSYS	Internal Systems
IRS	Interface Requirements Specification
ISS	International Space Station
ITCS	Internal Thermal Control System
IV&V	Independent Verification and Validation
IVVP	IV&V Plan
JEM	Japanese Experiment Module
JPAR	Joint Program Assessment Review
JSRP	Joint Software Review Panel
LOS	Line of Sight
MDM	Multiplexer/Demultiplexer
MT	Mobile Transporter
NCS	Node Control Software
PCS	Portable Computer Software
PMCA	Power Module Control Assembly
PVCA	Photovoltaic Control Assembly
RGAC	Radiator Goal Angle Calculation
RPCM	Remote Power Control Module
SARJ	Solar Alpha Rotary Joint
SDD	Software Design Document
SDMS	Structural Dynamic Measurement System
SEPS	Secondary Electrical Power Supply

SMC	Station Mode Control
SORR	Stage Operations Readiness Review
SRS	Software Requirements Specification
SSAS	Segment Attach System
SSPCB	Space Station Program Control Board
STRR	Software Transition Readiness Review
TCS	Thermal Control System
TDRS	Tracking and Data Relay Satellite
TRRJ	Thermal Radiator Rotary Joint

2.0 ISS Software Descriptions

2.1 Command and Control Software (CCS)

The C&C MDM CSCI is a component of the Station Management and Control (SMC) end item within the United States On-orbit Segment (USOS) of the International Space Station (ISS).

The C&C MDM CSCI performs Station level control, Command and Data Handling (C&DH), and Communications functions. The CSCI performs control and monitor functions: isolate fire control zone, remote power control, rack power control, control Laboratory Cradle Assembly, MDM and bus fault detection and recovery, robotic workstation interface, control of video tape recorders and of the Communications Outage Recorder, and distributed heater control.

Station level control necessary to accomplish mission operations and to handle contingency situations is provided. Station level control is accomplished by establishing Station level modes, vehicle safing in response to electrical and thermal failures, and control of a Caution and Warning capability.

C&DH functions include control bus management, high rate data link and hard disk control, and communications. C&DH communications includes data acquisition from and distribution to next level down processors, time management and time broadcast, and command processing.

Communications functions include management of S-Band and Ku-Band communications with the ground, UHF communications with nearby vehicles and with crew members performing EVA, and internal audio and video capability.

2.2 Node Control Software (NCS)

The NCS is considered to be an “end item” of the United States On-orbit Segment (USOS) of the ISS. It provides for control of the equipment located in the USOS portion of the Space Station prior to the arrival of the Command and Control (C&C) MDM on flight 5A. After 5A the NCS provides control primarily of the Node 1 portion of the

USOS. During early operations the NCS supports activation and assembly of the vehicle. It provides closed loop control of environmental, heater, and thermal systems. The NCS allows operator controlled activation of the primary and secondary power and thermal control systems. It routes data to support monitoring and commanding by ground-based operators and other vehicles. This software is applicable to Space Station stages 2A through Assembly Complete. This requires that the NCS, which is resident in two MDMs operating at the same time, be adaptive depending on each flight's hardware configuration.

2.3 Portable Computer System (PCS)

The Portable Computer System (PCS) is the ISS crew interface for commanding and monitoring the ISS vehicle hardware and associated software (Core Systems) via the Command and Control (C&C) MDM. PCS can either be directly connected to the C&C MDM or access the C&C MDM in a "pass-through" mode via the Guidance, Navigation, and Control (GN&C) MDM or the Primary Node 1 MDM. Pass-through operation is handled by the GN&C or Node 1 MDM software and is transparent to the PCS application. However, the PCS user may experience a delay in the application response time due to the extra layer of communication.

Core Systems status is determined via Caution & Warning information and telemetry data received from the C&C MDM. The hardware contained in each vehicle element (i.e. FGB, Node 1, and US Laboratory) is divided into vehicle systems for control and monitoring. The vehicle systems include Electrical and Power System (EPS), Thermal Control System (TCS), Command and Data Handler (C&DH), Communication and Tracking (C&T), Motion Control System (MCS), Environment Control and Life Systems Support (ECLSS), Crew Health Care System (CHeCS), Structures and Mechanism (S&M), Extravehicular Activity (EVA), and Mobile Servicing System (MSS).

PCS can also be used to control and monitor Payload Systems via the Payload MDM. PCS does not directly access Payload Systems, but provides an interface for executing payload-specific applications used to perform the necessary control and monitoring functions.

2.4 Guidance Navigation and Control (GNC)

The GNC CSCI provides navigation, attitude determination and attitude control (nonpropulsive) of the ISS vehicle to the required accuracy, even under specified conditions of single failures. The GNC is able to request the firing of the Russian thrusters to desaturate the Control Moment Gyroscope (CMG), if needed. The GNC CSCI also provides pointing of solar collectors, thermal radiators, antennas and other articulated appendages, generic pointing data to ISS users.

2.5 External Control Zone (ECZ)

The ECZ functionality includes:

DSM_EXT capability - DSM SW provides MDM initialization; time keeping and distribution; processor fault detection, isolation and recovery; memory load and dump; and communications bus input/output (I/O) processing. Includes initialization of the ECZ MDMs Integrated Truss Segments (ITSs) Starboard 3 (S3), Starboard 1 (S1), Starboard 0 (S0), Port 1 (P1), Port 3 (P3) Starboard Thermal Radiator (STR) and Port Thermal Radiator (PTR).

MT capability - The MT is a mobile base for systems such as the Space Station Remote Manipulator System (SSRMS), which enables the mobilization of payloads and other assembly and maintenance equipment along the external truss segments Starboard 4 (S4), S3, S1, S0, P1, P3 and Port 4 (P4). When not translating, the MT is latched to the station truss at a worksite (location of utility ports and latch sites). MT SW commands and controls the MT and Trailing Umbilical System (TUS) devices including: MT worksite latching and utility port mating mechanisms, MT transmission and drive mechanisms, and TUS reel assembly. Following operator command, MT SW automates MT translation between worksites. All MT and TUS devices employ the Integrated Motor Controller Assembly (IMCA), a generic obedient motor controller. For more information on the IMCA see Specification SP-M-547.

SSAS capability - SSAS is a remotely controlled mechanism which attaches adjacent truss segments during station assembly. There are four SSASs, one between each of the five EXT truss segments: S0 to S1, S0 to P1, S1 to S3 and P1 to P3. Each SSAS devices includes an IMCA driven latch and a bolting assembly. The bolting assembly is which

are driven by Bolt Bus Controller (BBC) HW logic device. For more information on the BBC see Drawing 1F70065. Upon operator command, SSAS SW controls and monitors SSAS devices.

CAS capability - CAS capability provides control for two different EXT attach systems: the UCCAS and the Attached Payload Attach System (PAS). Both attachment systems have an IMCA driven latch and an IMCA driven Umbilical Mechanism Assembly (UMA) as active components. UCCAS provides remotely controlled attachment of logistics racks on the P3 truss segment. The PAS provides a remotely controlled attachment of payload racks on the S3 truss segment. Both PAS and UCCAS provide power, data and video. Upon operator command, CAS SW controls and monitors both the UCCAS devices and PAS devices.

EATCS_M capability - The EATCS collects thermal energy through heat exchangers (HXs) that interface with internal thermal control systems of the Laboratory Module (LAB), Node and Habitation Module (HAB), and cold plates on externally mounted Electrical Power System (EPS) components. Heat is distributed in two independent and functionally equivalent liquid ammonia filled continuous loops. Waste heat is rejected by the thermal radiators. (See TRRJ_M below.) EATCS SW in the EXT MDM coordinates the activities of the lower level MDMs (S1/P1, S0, Starboard Thermal Radiator (STR)/ Port Thermal Radiator (PTR)) which provide EATCS component control. Functions, which the EATCS SW provides include, loop startup, loop venting and Fault Detection, Isolation and Recovery (FDIR).

TRRJ_M capability - The thermal radiator is a one degree of freedom articulating fin that radiates waste thermal energy. TRRJ provides rotational position of the thermal radiator; structural support between the S1/P1 structures and the radiator; and transfer of secondary power, data and single phase ammonia across the rotary interface. The TRRJ_M capability provides control and monitoring for rotational positioning of both the starboard and port thermal radiators, and TRRJ subsystem management for lower level MDMs on segments S1 and P1.

SEPS_EXT capability - Remote Power Controller Modules (RPCMs) distribute secondary electrical power to elements on EXT truss segments. SEPS SW controls and monitors power on/off switches in RPCMs on truss segments S3, S1, S0, P1 and P3, as

well as the RPCMs physically located on the MT. SEPS_EXT capability (1) collects and monitors RPCM sensor data and commands the RPCM firmware for MT RPCMs, (2) routes RPCM commands to and from lower tier (LT) SEPS capabilities and (3) manages LT RPCM bus controller assignments.

HC_EXT capability - The EXT PTCS heater control (HC_EXT) performs closed and open loop heater control for the RPCMs located on the MT. The EXT PTCS consists of a number of heaters and temperature sensors.

For each heater there is a heater circuit from which the SW receives temperature data from one or more temperature sensors and controls the on/off states of the associated heater by generating heater device power on/off requests which are processed by SEPS The PTCS architecture in many cases includes some redundant means of providing heat to a specific device from a distinct heater control domain. In some cases, this redundant means of providing heat is another heater circuit, and, in other cases, it is the operational power of the device itself. There is no redundancy across MDMs for heater control, because temperature sensors for an Orbital Replaceable Unit (ORU) needing heat are connected only to a single MDM.

SARJ_M capability – The SARJs, in conjunction with the beta rotary joint, are used to position the electrical power generation system (EPS) solar arrays. The port and starboard SARJ provide controlled rotation (360 degrees) of the EPS solar arrays, transfer of power and data across the rotary interface and structural support of the outboard segments, S4 and P4. The SARJ_M capability provides system management for both the starboard (S3) and port (P3) MDM pairs , and control and monitoring for rotational positioning of both the starboard and port EPS solar arrays.

RGAC capability – The RGAC capability determines the desired starboard and port thermal radiator orientation or goal angle for use by the TRRJ_M capability based on GN&C inputs and various measurements from the EATCS cooling loop.

ECZ_M capability – The ECZ_M capability provides support for TRRJ_M and EATCS_M operations. ECZ_M includes the automated means to perform recovery reconfiguration for SEPS user buses and supports a reset command to halt the configuration management features.

2.6 Power Management and Control Application/Photovoltaic Control Assembly (PMCA/PVCA)

The PMCA provides a software interface to the Photovoltaic Controller Unit (PVCU), Main Bus Switching Unit (MBSU), DC/DC Converter Unit (DDCU), Remote Power Controller Module (RPCM), and the Command and Control (C&C) MDM.

The PVCA provides a software interface to the PV Module equipment for the Power Management Controller Application (PMCA) CSCI and the Control Tier.

2.7 Internal Control Software/Hub Control Software (INTSYS/HCS)

The INTSYS CSCI includes all the application software in the INT MDM, and provides capabilities for the Electrical Power System (EPS), the Environmental Control and Life Support System (ECLSS), the Vacuum System (VS), and the Internal Thermal Control System (ITCS). The EPS software performs command formatting/execution and status monitoring for the EPS rack Remote Power Controller Module (RPCM). The ECLSS capabilities include Atmosphere Control and Supply (ACS), Atmosphere Revitalization (AR), Fire Detection System (FDS), Temperature and Humidity Control (THC), and Water Recovery (WR). The ITCS software provides automated element thermal system initiation, pump package interface to the pump/fan motor controller, time critical failure recovery, and element level failure detection and isolation for the USL and Node 2 modules.. Command and Data Handling responsibilities are performed by the MDM Utilities Extension (MUE) capability. The MUE capability provides support the C&C–to–INT command pipes required for AR Sample Distribution Valve control, and to manage communication with the Node 3 PCA and MCA.

The HCS CSCI provides command and data handling and control of the Caution and Warning, Secondary Electrical Power System (SEPS), Common Berthing Mechanism (CBM), Active and Passive Thermal and Environmental Control and Life Support (ECLS) devices in Node 3, Cupola and PMA-3, as well as an interface to the Crew Return Vehicle (CRV) and required interfaces with and control of the Multi-Purpose Logistics Module (MPLM). Additionally, the HCS provides a data communication path from the Hub Control Zone to the ISS via communication as a MIL-STD-1553B Remote

Terminal (RT) with the Command and Control (C&C) MDM. Hardware scars are provided for 1553B communication paths to the CRV and Habitation module.

2.8 Tier 3 Software

This category of software includes the following CSCIs: Lab Systems 1 (LSYS1), Lab Systems 2 (LSYS2), Lab Systems 3 (LSYS3), Node 2 Systems 1 (N2SYS1), Node 2 Systems 2 (N2SYS2), Node 3 Systems 1 (N3SYS1), and Node 3 Systems 2 (N3SYS2). The functionality of these CSCIs includes some or all of the following capabilities: Environmental Control and Life Support System (ECLSS), Internal Thermal Control System (ITCS), and Electrical Power System (EPS). The ECLSS capabilities include the Air Revitalization (AR) Sample Delivery System, the Atmosphere Control and Supply (ACS) Distribution, the Fire Detection System (FDS) subsystem, the Avionics Air Assembly (AAA), the Common Cabin Air Assembly (CCAA) and the Intermodule Ventilation Control (IVC) portions of the Temperature and Humidity Control (THC) subsystem; and the Water Recovery Port Vent Assembly (WRPVA) and the the Water Recovery (WR) subsystem. The ITCS capabilities include Accumulator Vent Valve (AVV), Heat Exchanger Bypass (HXB) valves, the Loop Crossover Assembly (LCA), the Passive ITCS (PTCS), the Pump Package Sensors, the Rack Flow Control Assembly (RFCA), the System Flow Control Assembly (SFCA), Nitrogen Introduction Valve (NIV) , the System Flow Control Assembly Shutoff Valve (SOV), and Rack Standalone Temperature Sensors (RSTS). The EPS software monitors the status of maintenance switches. The Guidance, Navigation & Control (GN&C) Attitude Control System (GACS) provides effector commands to the talk–back panel moding indicators on the Pressurized Mating Adapter (PMA) when commanded by the ground or crew and provides mating/demating sensor data cyclically from the PMA.

3.0 ISS Software Integrity Level (SIL)

Tables 3.1 – 3.8 list the Software Integrity Level for the ISS software. One corresponds to low, two corresponds to medium and three corresponds to a high level.

Table 3.1 CCS SIL

CCS Functionality	1	2	3
Station Mode & State Control			X
RPCM Control			X
Vehicle Retry & Safing Mgt			X
Vehicle Safing		X	
Control Bus MDM Management		X	
Annunciate Alarms			X
Manage C&T		X	
Maintenance Switch Control			X
DDCU Control			X
Isolate Fire Control Zone		X	
Manage Resources			X
C&DH Functions			X
System CM			
Robotics Workstation		X	
1553 Bus FDIR		X	
C&C MDM FDIR		X	
Distributed Heater Control			X
Manage Attitude Control Handovers between U.S. and Russian Segments			X
JEM Control and Monitoring			X
APM Interface			X
Control CBM			X

Table 3.2 NCS SIL

NCS Functionality	1	2	3
Telemetry Control			X
Environmental Control			X
Heater Control			X
Primary Power Control			X
Secondary Power Control			X
Common Berthing Mechanism			X
Attitude Control System Moding			X
Annunciate Alarms			X
System Configuration Management			X
Time Management			X
Command Processing and Communications			X
Input and Output Control			X
1553 Bus FDIR			X
NCS MDM FDIR			X
Provide Data to Early PCS			X

Table 3.3 PCS SIL

PCS Functionality	1	2	3
External Interface Requirements			X
1553 Interface Capability			X
Command Capability		X	
Display Capability			X
File transfer Capability			X

PCS Functionality	1	2	3
Caution and Warning Capability			X
Time Services Capability			X
PCS Status Capability			X
Internal Interfaces			X
Crew Interface Inputs			X
Crew Interface Outputs			X
Crew Interface Processing			X
Crew Interface Error Handling			X
Robotic Workstation			X
Space Station Remote Manipulator System			X
Mobile Base System			X
Special Purpose Dexterous Manipulator			X

Table 3.4 GNC SIL

GNC Functionality	1	2	3
Sequence Commands			X
Sequence Sensors and Effectors Capability			X
Sequence Operational States			X
GPS Control & Monitor			X
State Determination			X
Attitude Determination		X	
RGA Control & Monitor			X
Control Attitude	X		
CMG Control & Monitor			X
Generic Data Computation			X
TDRS/Solar LOS Computation			X
TDRS/Solar Rise/Set			X
Computation			X
Mass Properties Computation			X
MDM Services			X

Table 3.5 ECZ SIL

ECZ Functionality	1	2	3
Data Manage ment System			X
Mobile Transporter			X
Segment to Segment Attach System (SSAS)			X
Common Attach System (CAS)			X
External Active Thermal Control System (EATCS) Capabilities		X	
Thermal Rotary Joint (TRRJ) Management		X	
Secondary Electrical Power System (SEPS)			X

ECZ Functionality	1	2	3
PTCS Heater Control			X
SARJ Management			X
RGAC			X
ECZM Computation			X

Table 3.6 PMCA/PVCA SIL

PMCA/PVCA Functionality	1	2	3
Control Primary Power Distribution		X	
System Execution and Control		X	
EPS FDIR		X	
Monitor EPS		X	
Control Power Generation Measurement System Management (SDMS_M)		X	
Control Energy Storage		X	
Control PV TCS		X	
Control Lab TCS		X	

Table 3.7 INTSYS/HCS SIL

INTSYS/HCS Functionality	1	2	3
Atmosphere Control		X	
Atmosphere Revitalization		X	
Fire Detection System			X
Temperature & Humidity Control			X
Water Recovery		X	
Electrical Power System			X
System Control for ITCS		X	

INTSYS/HCS Functionality	1	2	3
Failure Recovery for ITCS		**X**	
Leak Recovery for ITCS		**X**	
Passive ITCS Control		**X**	
ITCS Pass-Through			**X**
Pump Package		**X**	
Guidance, Navigation and Control			**X**
CBM Control			**X**

Table 3.8 TIER 3 SOFTWARE SIL

TIER 3 Software Functionality	1	2	3
Atmosphere Control			X
Atmosphere Revitalization			X
Fire Detection System			X
Temperature & Humidity Control			X
Water Recovery			**X**
Heat Exchanger Bypass			X
Loop Crossover Assembly			X
Passive Thermal Control			X
Pump Sensors			X
Rack Flow Control Assembly		X	
System Flow Control Assembly		X	
Shutoff Valve		X	
Accumulator Vent Valve		X	
Nitrogen Introduction Valve		X	
Rack Standalone Temp Sensor			X
EPS			X
GN&C			X

TIER 3 Software Functionality	1	2	3
Caution & Warning Panel			X
Attached Pressurized Module			X